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ABSTRACT

Many syntactic and semantic studies have focused on the distribution of closed-class lexical noun phrases (NPs) such as "her, herself, and each other." Recent work has demonstrated that many other NPs are also referentially dependent. A model-theoretic semantic analysis of a number of such referentially dependent NPs is presented. These NPs are interpreted as functions that map two-place relations onto predicates that are true or false of sets of individuals. The analysis allows NPs to be classified according to their degree of dependency as specified by four semantic conditions on higher-order functions. Furthermore, distinctions made by these semantic conditions correlate with differences in syntactic distribution. It is also shown that properties associated with bound variable pronouns generalize to the full class of referentially dependent NPs. For example, referentially dependent NPs do not have a bound reading in weak crossover contexts. However, unlike pronouns, these higher-order NPs appear to discriminate between crossover environments at surface structure and logical form. (MSE)

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A Semantic Characterization of Referentially Dependent Noun Phrases

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0. Introduction
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0. Introduction

In this paper, I will present a formal semantic characterization of referentially dependent noun phrases. Intuitively, these are noun phrases (NPs) whose interpretation depends on the interpretation of another NP in the same sentence. Pronouns such as she, her, and herself are the most obvious members of this class. However, in this paper, I will limit my discussion to the higher-order referentially dependent NPs, such as those illustrated in (1) - (4).

(1) a. The men hit each other.
b. Some students saw each other's scores.
c. At least three politicians criticized each other but not each other's spouses.

(2) a. Alice and Bob reviewed a different book.
b. The two suspects belong to rival gangs.
c. The witnesses gave conflicting evidence.

(3) a. Three editors read the same books.
b. Most applicants submitted the same number of references.
c. The reviewers selected the same student's papers.

(4) a. Two authors wrote a total of nine plays.
b. The guards fired a minimum of six rounds.
c. The carrells in the reading room accommodate a maximum of 12 students.

I refer to these NPs as "higher-order" in the sense that they map a transitive verb denotation to a function which is true or false of sets of individuals. In a certain model, ||[criticize each other]|| might be a function which maps the set of students to false and maps the set of teachers to true. This contrasts with a "lower-order" NP such as herself which combines with criticize to form a function that is true or false of individuals. For example, ||[criticize herself]|| might be true of Alice but false of Betty.

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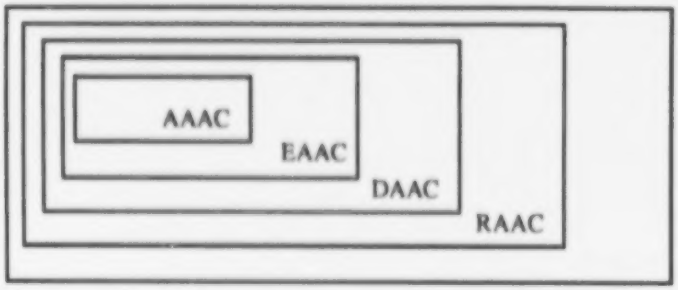
Given this view of NP denotations, I will define four classes of (higher-order) referentially dependent NPs. The classes form an implicational hierarchy, as illustrated in (5), where each subclass is a proper subset of the next superclass.

(5)



These semantic classes correlate with differences in syntactic distribution, although more work is required to define the licensing conditions for each class.

1. Reciprocals

Reciprocal noun phrases of the type illustrated in (1) are interpreted as functions of a certain sort. They map two-place relations onto predicates that are true or false of sets of individuals. Formally, the set of all such functions is referred to as $[\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$, where **R** is the set of two-place relations, **P** is the set of properties, and **2** is the set of truth values {0,1}. For example, the following definition for |[each other]| was given by Langendoen (1978).[1]

(6) Definition. $|[\text{each other}]| \in [\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ such that for all $A \in \mathbf{P}$ and all $R \in \mathbf{R}$, $|[\text{each other}]|(R)(A) = 1$ iff

$(\forall x \in A)(\exists y,z \in A)(x \neq y \ \& \ x \neq z \ \& \ xRy \ \& \ zRx)$.

In a simple model like (7), the sentence "Alice and Betty rebuked each other" will be true, while "Vicki and Wilma slandered each other" will be false.

(7)

More complex reciprocals, like each other's papers will also denote in the set of functions $[\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ (Tyhurst 1989). However, we would like to know if all such

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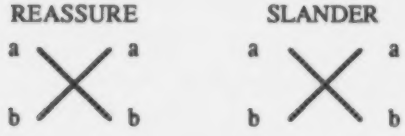
[1] The exact statement of the function |[each other]| is not crucial to the arguments in this paper. The definition above is Langendoen's "weak reciprocity". However, even if we require "strong reciprocity" for reciprocals (Fiengo and Lasnik 1973, Heim, Lasnik, and May 1988), the classes of referentially dependent NPs that I propose will remain unchanged.

functions are denotable by natural language expressions. Consider the model in (8) below. In this very simple case, Alice rebuked the same people that she slandered. Similarly, Betty rebuked the same people that she slandered.

(8)



In any model of this type, it must be the case that "Alice and Betty rebuked each other" has the same truth value as "Alice and Betty slandered each other". This means that |[each other]| remains invariant under substitution of one relation for another as long as a certain condition is met. Not all functions in $[\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ have this property, so it is a claim about the range of possible denotations of natural language expressions. Keenan (1988) formalized this intuition in the following condition.

(9) Reducible Accusative Anaphor Condition (RAAC) (Keenan 1988)
A function $H \in [\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ is a reducible accusative anaphor iff
for all $R, S \in \mathbf{R}$, all $A \in \mathbf{P}$,
if $aR = aS$ for all $a \in A$ then $H(R)(A) = 1$ iff $H(S)(A) = 1$,
where $aR =_{def} \{b \mid \langle a,b\rangle \in R\}$.

Since most functions in $[\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ do not satisfy this condition, we are making a significant claim about the limitations on natural language denotations. In a model with a universe of discourse containing n individuals, the number of functions in the set $[\mathbf{R}\rightarrow[\mathbf{P}\rightarrow\mathbf{2}]]$ is given by the following formula:

$$|\,[\mathbf{R} \rightarrow [\mathbf{P} \rightarrow \mathbf{2}]]\,| \;=\; 2^{2^{(n^2+n)}}$$

However, the number of functions satisfying the RAAC is only:

$$2^{\sum_{j=0}^{n} [\binom{n}{j} 2^{n \cdot j}]}$$

For example, the following table shows the number of functions involved for very small universes. While the number of functions satisfying the RAAC is very large, it is still *much* smaller than the total number of functions.

	n = 2	n = 3
$2^{\sum_{j=0}^{n} [\binom{n}{j} 2^{n \cdot j}]}$	2^{25}	2^{729}
$2^{2^{(n^2+n)}}$	2^{64}	2^{4096}

2. Subclasses of referentially dependent NPs

Anaphoric properties of referentially dependent NPs

It has been noted previously that NPs like those in (2) - (4) have a reading in which they are not interpreted independently of other NPs in the sentence (Scha 1981, Stump 1982, Dowty 1985, Clark and Keenan 1986, Keenan 1987, Carlson 1987). These NPs exhibit several properties associated with pronouns, the prototypical referentially dependent NPs. First, sentence (10) illustrates that there is an ambiguity between a sentence bound reading and a deictic interpretation of the same story.

(10) Every counselor told the same story to two campers.

There may be some story identified in the context of the utterance which the same story refers to. That is the deictic interpretation. It is also possible for the same story to be bound by either the subject NP or the indirect object. When it is bound by the subject NP, the intended reading is that each counselor told story #1 to camper #1, each counselor told story #2 to camper #2, etc. There is another reading, perhaps the preferred one, where counselor #1 told story #1 to two campers, counselor #2 told story #2 to two campers, etc. Thus, one of the anaphoric properties of pronouns extends to this more general class of referentially dependent NPs. There is a deictic vs. sentence bound ambiguity and binding within a sentence is sometimes ambiguous.

A second property of referentially dependent NPs is that there are locality conditions on potential antecedents. Sentence (11) shows that different books cannot be bound by the main clause object her teachers. That sentence cannot mean that Alice promised teacher #1 to read book #1, teacher #2 to read book #2, etc. The lack of a sentence internal reading is indicated by a pound sign (#) in front of the sentence.

(11) #Alice promised her teachers to read different books.

Further study is required in order to provide an adequate specification of the licensing conditions for the referentially dependent NPs (but see Clark and Keenan 1986 and Carlson 1987 for proposals in this regard).

A third property of referentially dependent NPs is number agreement with the antecedent NP. Sentences (12a,b) illustrate this for different. Sentence (12a) with the plural different machines does not have a sentence internal reading where technician #1 monitors machine #1, technician #2 monitors machine #2, etc. In (12b), the plural subject requires a plural object in order to have a sentence internal reading.

(12) a. Every technician monitors a different machine.
#different machines

b. Those three authors have very distinct styles.
#a very distinct style

A fourth property of referentially dependent NPs, which has not been discussed in the literature, is the crossover phenomena. In the classic example of Weak Crossover of (13), the pronoun his cannot be bound by the Wh-operator (or the trace).

(13) *Who$_i$ does his$_i$ mother love t$_i$?

In (14a), there is a dependent reading where assistant a1 called juror j1, a2 called j2, and a3 called j3. However, this is not a possible reading for (14b).

(14) a. The same lawyer's assistants called three jurors.
b. #Who$_i$ did the same lawyer's assistants call t_i?

(15) a. Different professors' students called the administrators.
b. #Who$_i$ did different professors' students call t_i?

(16) a. Two administrators from the same college tried to recruit Elliott and Fred.
b. #Who$_i$ did two administrators from the same college tried to recruit t_i?

To summarize, the notion of "anaphor" generalizes from the closed class of pronouns to an open class of referentially dependent NPs. These NPs exhibit four properties normally associated with pronouns: deictic vs. sentence bound ambiguity, locality conditions on the antecedent NP, number agreement, and crossover phenomena.

Semantic interpretation in simple transitive sentences

I will present a model-theoretic interpretation for some referentially dependent NPs when they occur as a direct object in a simple transitive sentence. A more complete analysis should account for a wider range of environments. It should also account for licensing elements other than antecedent NPs, such as coordinate structures and adverbs. However, for the purposes of this paper, it will be sufficient to consider the limited domain where a referentially dependent NP occurs as a direct object which is licensed by the subject NP. This will be sufficient to categorize the NPs according to the semantic conditions given later. First, let's consider NPs of the form a total of n N, where n is some natural number and N is a common noun. One of the readings available with this expression also occurs with a bare numeral determiner.

(17) a. Less than a dozen girls sold a total of 243 calendars.
b. Alan and Bob washed five cars between them.
c. Three demonstrators broke (a total of) nine windows (between them).

The reading of interest in (17a) is the one which simply adds up the number of calendars that were sold, regardless of which girls actually did the selling. This is distinct from a simple object-wide scope reading which would entail that each calendar was sold a number of times. Furthermore, it is not equivalent to a collective reading in which the girls somehow worked together to sell each calendar. Partee (1975) calls this the total-total reading. Scha (1981) calls this the "cumulative quantification" reading.

We can represent the interpretation of a total of 243 calendars in the following way. Suppose we have a non-empty set, **E**, called the universe of discourse. Objects in this set will correspond to objects in the world that we want to model. A transitive verb will denote a two-place relation represented as a set of ordered pairs. For example, SELL might denote the relation { <a,c1>, <a,c2>, <b,c23>, ... , <z,c567> }, where <x,y> $\in$ SELL represents the fact that 'x sold y'. We call the set of all such relations **R**, where **R** = **(ExE)***, i.e. **R** is the powerset of **ExE**. Common nouns denote subsets of **E**, called properties. For example, CALENDAR might denote the set {c1, c2, ..., c567}. The set of all such properties is called **P**, where **P** = **E***. The entire NP, a total of 243 calendars, will denote a function that maps the SELL relation onto a function that maps properties to truth values. Intuitively, |[sell a total of 243 calendars]| will be true

of a set of individuals just in case the total number of calendars sold by individuals in this set adds up to 243. The general case is defined as follows:

(18) Definition of 'A TOTAL OF n': For all A, $Q \in \mathbf{P}$, all $R \in \mathbf{R}$, and all $n \in \mathbf{N}$,
((A TOTAL OF n)(Q))(R)(A) = 1 iff $|(\bigcup_{a \in A} aR) \cap Q| = n$

Suppose we want to know if Yolanda and Zoe sold a total of 243 calendars. By the definition above, ((A TOTAL OF 243)(CALENDAR))(SELL)({y,z}) = 1 iff |(ySELL ∪ zSELL) ∩ CALENDAR| = 243. First, we take the union of ySELL (the things that Yolanda sold) with zSELL (the things that Zoe sold). Then we take the intersection of that set with CALENDAR (the extension of calendars in the model) to get the set of calendars that were sold either by Yolanda or Zoe. The cardinality of this set must be 243 in order for it to be true that Yolanda and Zoe sold a total of 243 calendars.

There are other English quantifier phrases like a total of which combine with a numeral and a common noun to form a referentially dependent NP. Formal definitions for the functions denoted by a minimum of and a maximum of are given below.

(19) Definition of 'A MINIMUM OF n': For all A, $Q \in \mathbf{P}$, all $R \in \mathbf{R}$, and all $n \in \mathbf{N}$,
((A MINIMUM OF n)(Q))(R)(A) = 1 iff $|(\bigcup_{a \in A} aR) \cap Q| \geq n$

(20) Definition of 'A MAXIMUM OF n': For all A, $Q \in \mathbf{P}$, all $R \in \mathbf{R}$, and all $n \in \mathbf{N}$,
((A MAXIMUM OF n)(Q))(R)(A) = 1 iff $|(\bigcup_{a \in A} aR) \cap Q| \leq n$

Using this notation, it is relatively straightforward to give the denotations for some of the other referentially dependent NPs that we are considering. To determine whether "Fred and Greg read the same books" is true, we simply need to compare the books that Fred read to the books that Greg read. In order for the sentence to be true, the two sets of books must be the same. This intuition is formalized in the following definition.

(21) Definition of 'SAME': For all A, $Q \in \mathbf{P}$, and all $R \in \mathbf{R}$,
(SAME(Q))(R)(A) = 1 iff |A| > 1 and for all $a,b \in A$, $aR \cap Q = bR \cap Q$.

Applying this definition to the sentence "Fred, Greg,and Harvey read the same books", we must determine whether | {f,g,h} | > 1 and fREAD ∩ BOOK = gREAD ∩ BOOK = hREAD ∩ BOOK. Thus, in order to determine if ||[read the same books]|({f,g,h}) = 1, we determine if the things that Fred read which are books (i.e. fREAD ∩ BOOK) are the same things that Greg read which are books (i.e. gREAD ∩ BOOK). Furthermore, these must be the same as the things that Harvey read which are books (i.e. hREAD ∩ BOOK). Remember that for all $x \in \mathbf{E}$, xREAD is the set of things that x read, i.e. xREAD = {b | <x,b> ∈ READ}.

The definition for the function DIFFERENT requires that each member of the "antecedent" participate in the relation. For example, "Fred and Greg read different books" entails that Fred read books and Greg read books. In addition, Fred did not

read any of the books that Greg read and Greg did not read any of the books that Fred read. These aspects of the meaning of different are represented in the following definition.

(22) Definition of 'DIFFERENT': For all A, Q ∈ **P**, and all R ∈ **R**,
(DIFFERENT(Q))(R)(A) = 1 iff
(a) |A| > 1; and
(b) for all a ∈ A, aR ∩ Q ≠ {}; and
(c) $\bigcap_{a \in A} aR \cap Q = \{\}$.

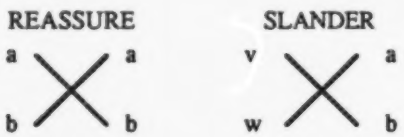
To determine if |[read different books]|({f,g}) = 1, we first use (22a) to see if |{f,g}| > 1. Then we check (22b) to see that fREAD ∩ BOOK ≠ {}, i.e. Fred read at least one book, and gREAD ∩ BOOK ≠ {}, i.e. Greg read at least one book. Finally, using (22c), we check that fREAD ∩ gREAD ∩ BOOK = {}, i.e. Fred and Greg did not read any of the same books. If each of the three clauses is satisfied, then |[read different books]|({f,g}) = 1 and |[Fred and Greg read different books]| = 1.

Semantic conditions

In addition to the Reducible Accusative Anaphor Condition presented earlier, I would like to consider semantic conditions which classify the higher-order referentially dependent NPs into 4 subclasses. The classes are defined by the invariance of the functions with respect to certain argument substitutions. For example, we noted in model (8) that |[each other]|(R)({a,b}) had to have the same truth value as |[each other]|(S)({a,b}). We could substitute S for R and preserve the same truth value as long as aR = aS and bR = bS.

Now consider the model of (23). In this case, Alice reassured the person who Vicki slandered and Betty reassured the person who Wilma slandered. In this situation, "Alice and Betty reassured different people" must have the same truth value as "Vicki and Wilma slandered different people".

(23)



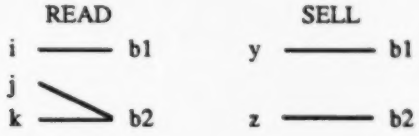
As noted earlier, "Alice and Betty reassured each other" does not have the same truth value as "Vicki and Wilma slandered each other". So we can subcategorize NPs like different people according to the following condition:

(24) Distributive Accusative Anaphor Condition (DAAC)
A function H ∈ [R→[P→2]] is a distributive accusative anaphor iff
for all R, S ∈ **R**, all A, B ∈ **P**,
if there exists a bijection π ∈ [A → B] such that for all a ∈ A, aR = π(a)S
then H(R)(A) = H(S)(B).

Some of the NPs that satisfy the DAAC are: a different book, a different student's book, two plays by different authors, distinct styles, separate facilities, (non-)adjacent apartments, neighboring buildings, (un)related dialects of Kenyang, parallel streets, streets that are parallel to each other, rival political parties, warring factions, conflicting reports, and reports that conflict with each other.

Within the NPs that satisfy the DAAC is another subclass exemplified by the same books. Consider the following model in which Ian read the book that Yolanda sold and Jim and Kate each read the book that Zoe sold.

(25)



For each member a of {i, j, k}, there is a member b of {y, z} such that aREAD = bSELL. Similarly, for each member b of {y, z} there is a member a of {i, j, k} such that bSELL = aREAD. Given this "back and forth" situation, NPs like the same books and the same number of books will assign the same truth values to the relation/property pairs. This is formalized in the following condition where {i, j, k} corresponds to the set A and {y, z} corresponds to set B.

(26) Equative Accusative Anaphor Condition (EAAC)
A function $H \in [\mathbf{R} \rightarrow [\mathbf{P} \rightarrow \mathbf{2}]]$ is an equative accusative anaphor iff
for all $R, S \in \mathbf{R}$, all $A, B \in \mathbf{P}$,
if $\{aR \mid a \in A\} = \{bS \mid b \in B\}$ then $H(R)(A) = H(S)(B)$.

Some NPs which satisfy the EAAC are: the same books, the same number of books, the same student's papers, two plays by the same author, and two papers from the same conference.

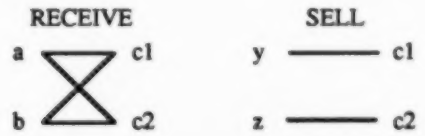
The final subclass of higher-order NPs is the Additive Accusative Anaphors defined by the following condition.

(27) Additive Accusative Anaphor Condition (AAAC)
A function $H \in [\mathbf{R} \rightarrow [\mathbf{P} \rightarrow \mathbf{2}]]$ is an additive accusative anaphor iff
for all $R, S \in \mathbf{R}$, all $A, B \in \mathbf{P}$,
if $\bigcup_{a \in A} aR = \bigcup_{b \in B} bS$ then $H(R)(A) = H(S)(B)$.

In a model like (28), the sentence "Alan and Bob received a total of 2 calendars" must have the same truth value as "Yolanda and Zoe sold a total of two calendars". That is,

((A TOTAL OF 2)(CALENDAR)(RECEIVE)({a,b}) =
((A TOTAL OF 2)(CALENDAR)(SELL)({y,z})

(28)



Similarly, it can be shown from the definitions of 'A MINIMUM OF' and 'A MAXIMUM OF' that the English expressions of the form a minimum of n N and a maximum of n N denote Additive Accusative Anaphors. Although I will not give a formal semantics for partitives (e.g. a bunch of the plates) and pseudopartitives (e.g. a cupful of jellybeans), one reading of these English constructions appears to require denotations which satisfy the AAAC.

In this section, I have shown that the examples in (2) - (4) exhibit properties commonly associated with pronouns. I gave an explicit semantics for some of these NPs and showed that their denotations form a very restricted subset of the set $[R \rightarrow [P \rightarrow 2]]$. Four conditions were used to subcategorize the higher-order referentially dependent NPs. The relationship between the NPs is schematized in the Venn diagram of (5). One may also view this relationship among the conditions as an implicational hierarchy, where AAAC < EAAC < DAAC < RAAC.

3. Syntactic correlates of the semantic conditions

I want to briefly consider some evidence that the semantic conditions proposed in the previous section correlate with differences in syntactic distribution. I do not have any definitive statements of the syntactic distribution for each class, but work in progress indicates that they do not have identical distribution.

Total, same, and different NPs differ from the reciprocals in being able to occur as the subject of a main clause:

(29) a. A total of 5 agents saw the intruders.
b. The same 5 agents saw the intruders.
c. Different agents saw the intruders.
d. *Each other saw the intruders.
e. *Each other's agents saw the intruders.

Only same, different, and complex reciprocals may occur as the subject of an embedded tensed clause:

(30) a. #The men believed a total of 12 lawyers called Alice.
b. The men believed the same lawyers called Alice.
c. The men believed different lawyers called Alice.
d. *The men believed each other called Alice.
e. The men believed each other's lawyers called Alice.

Intuitively, the total NPs are the least anaphoric of the referentially dependent NPs considered here. This intuition is captured in the semantic conditions, since the additive anaphors are the least discriminating, i.e. they are invariant under a wider range of substitutions. The weak anaphoricity of total NPs shows up in the syntax as well. These are the only referentially dependent NPs that occur in crossover constructions. In

my judgment, the following two sentences have a bound reading, although it is not the preferred one.

(31) a. Which donors$_i$ did a total of 5 volunteers call t_i?
b. The potential donors that$_i$ a total of 12 volunteers in California called t_i were just as likely to contribute more than $100 as those who$_j$ t_j were called by a total of 15 volunteers in New York.

Equative anaphors are the only ones that may be bound in the indirect object position of the double object construction:

(32) a. #Ben told a minimum of twelve children three stories.
b. Ben told the same children three stories.
c. #Ben told different children three stories.

If the four classes of referentially dependent NPs were completely independent with respect to syntactic distribution, it should be possible to find 16 different combinations of them. For example, there should be one environment where only additive anaphors occur, one environment where only equative anaphors occur, etc. In the Appendix, I made a table that lists the 16 logically possible combinations of the four classes. So far, I have found environments to distinguish 10 of the 16 cases. Although speakers' judgments may vary on particular cases, it appears that the four semantic classes correlate with differences in syntactic distribution. It remains to show the exact syntactic licensing conditions for each class.

4. Conclusion

Many syntactic and semantic studies have focused on the distribution of closed-class lexical NPs such as her, herself, and each other. Recent work has demonstrated that many other NPs are also referentially dependent (Carlson 1987, Keenan 1987). In this paper, I provided a model-theoretic semantic analysis of a number of such referentially dependent NPs. These NPs are interpreted as functions which map two-place relations onto predicates that are true or false of sets of individuals.

This analysis allows NPs to be classified according to their degree of dependency as specified by four semantic conditions on higher-order functions. Furthermore, distinctions made by these semantic conditions correlate with differences in syntactic distribution. It was also shown that properties associated with bound variable pronouns generalize to the full class of referentially dependent NPs. For example, referentially dependent NPs do not have a bound reading in weak crossover contexts. However, unlike pronouns, these higher-order NPs appear to discriminate between crossover environments at surface structure and logical form.

Appendix. Distribution of higher-order noun phrases.

In the table below, sample sentences contain a blank (__) for one noun phrase position and an underlined NP to serve as a potential antecedent (e.g. they). If one of the higher-order NPs can fill in the blank and be bound by the other underlined NP, then a plus sign (+) is shown in the appropriate column. The letter c in the 'each other' column indicates that a complex reciprocal, such as each other's sisters is acceptable in this position, although the bare reciprocal each other may not be.

		total	same	different	each other
1	Subject of infinitival clause The men wanted __ to be hired.	+	+	+	+
2	Subject of main clause __ saw the students. Antecedent in subordinate clause __ verified that the athletes were eligible.	+	+	+	
3	PRO gate Dating __ upset Alice and Bonnie.	+	+		+
4		+	+		
5		+		+	+
6		+		+	
7		+			+
8	Strong Crossover Who$_i$ did __ call t$_i$?	+			
9	Object of infinitival clause The men wanted Alice to hire __.		+	+	+/c
10	Subject of tensed clause (opaque) They believed __ called Alice.		+	+	
11	Subject of tensed clause They said __ had called the customers.		+		+/c
12	Agent by-phrase in subordinate clause Mike and Bob think that America was discovered by __. Double object Ben told __ every story.		+		
13				+	+
14				+	
15	Object of tensed clause The lab managers hoped that the NSF would fund __.				c
16	Object of infinitival (Subject control) Alice promised her teachers to find __.				

References

Carlson, Greg N. 1987. Same and different: some consequences for syntax and semantics. Linguistics and Philosophy 10, 531-565.

Clark, Robin L., and Edward L. Keenan. 1986. On the syntax and semantics of binary (n-ary) quantification. Proceedings of the West Coast Conference on Formal Linguistics (Volume 5), University of Washington, March 28-30, 1986. pp. 13-28.

Dowty, David R. 1985. A unified indexical analysis of same and different: A response to Stump and Carlson. Presented at the University of Texas Workshop on Syntax and Semantics, Austin, Texas, March 22-24, 1985.

Fiengo, Robert, and Howard Lasnik. 1973. The logical structure of reciprocal sentences in English. Foundations of Language 9, 447-468.

Heim, Irene, Howard Lasnik, and Robert May. 1988. Reciprocity and plurality. To appear in R. May (ed.), Essays on Logical Form.

Keenan, Edward L. 1987. Unreducible n-ary quantifiers in natural language. In Peter Gärdenfors (ed.), Generalized Quantifiers: Linguistic and logical approaches. Dordrecht: D. Reidel Publishing Company.

Keenan, Edward L. 1988. Complex anaphors and Bind α. In Lynn MacLeod, Gary Larson, and Diane Brentari (eds.), CLS 24: Papers from the 24th annual regional meeting of the Chicago Linguistic Society (Part One: The General Session). pp. 216-232.

Langendoen, D. Terence 1978. The logic of reciprocity. Linguistic Inquiry 9:2, 177-197.

Partee, Barbara H. 1975. Comments on Fillmore's and Chomsky's papers. In Robert Austerlitz (ed.), The Scope of American Linguistics. Lisse: The Peter de Ridder Press. pp. 197-209.

Scha, Remko. 1981. Distributive, collective and cumulative quantification. In Jeroen Groenendijk, Theo M.V. Janssen, and Martin Stokhof (eds.), Formal Methods in the Study of Language, Vol. II. Amsterdam: Mathematische Centrum. pp. 483-512. Reprinted in Groenendijk, Janssen, and Stokhof (eds.). 1984. Truth, Interpretation, and Information. Dordrecht: Foris.

Stump, Gregory. 1982. A GPSG fragment for 'dependent nominals'. Unpublished paper, Ohio State University.

Tyhurst, James J. 1989. Complex reciprocals in English. Presented at the ASL/LSA Conference on Logic and Linguistics, University of Arizona, Tucson, July 23-24, 1989.